Meson Test Beam Upgrade

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September 18, 2006

List of MTBF Memoranda of Understanding (MOU):

T926: RICE Experiment completed
T927: BTeV Pixel Experiment completed
T930: BTeV Straw Experiment completed
T931: BTeV Muon Experiment completed
T932: Diamond Detector Signed
T933: BTeV ECAL Experiment completed
T935: BTeV RICH Experiment completed
T936: US/CMS Forward Pixel Taking data
T941: UIowa PPAC Test Experiment completed
T943: U. Hawaii Monolithic Active Pixel Detector Experiment completed
T950: Kaon Vacuum Straw Tracker Analyzing data
T951: ALICE EMCAL Prototype Test Analyzing data
T953: U. Iowa Cerenkov Light Tests Analyzing data
T955: RPC Detector Tests (Argonne) Taking data
T956: ILC Muon Detector Tests (Indiana) Taking data
T957: ILC Tail Catcher (NIU) Taking data
T958: FP420 Fast Timing Test Taking data
T959: Microparticle Shielding Assessment In review

From Erik Ramberg (MTest Facility Coordinator) - www-ppd.fnal.gov/MTBF-w/
ILC input - Marcel Demarteau (Fermilab ILC Detector Group)

Upgrading the Test Beam

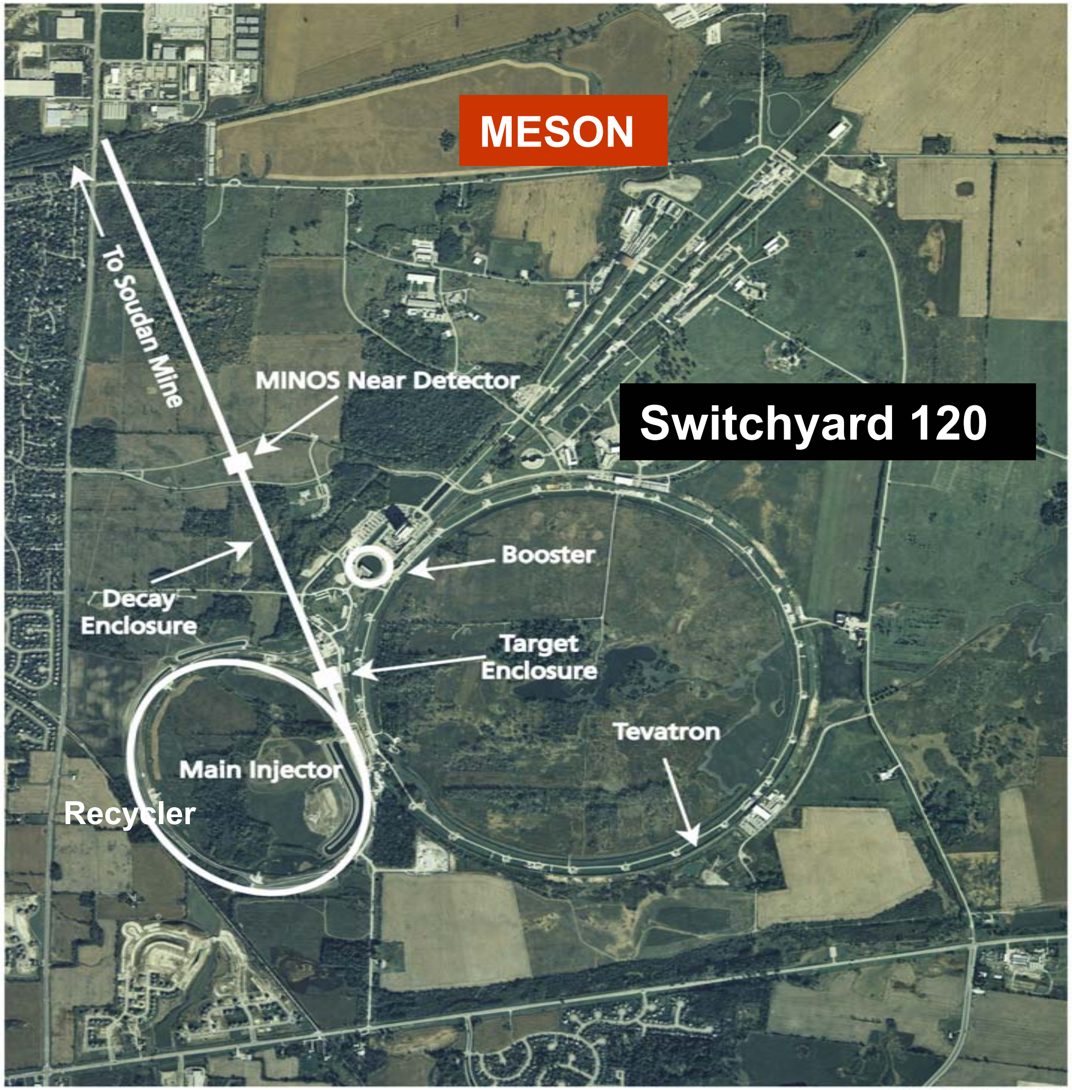
- The proposal to test ILC calorimetry at Fermilab (TM-2291) indicates a need for low energy pions (1 GeV) and high energy electrons (25 GeV).
- Both of these beam types are difficult in the current test beam due to the length of the beamline and sheer number of windows, scintillators, etc.
- The External Beams Group has completed a design to install a movable target in the M03 enclosure and redesign the downstream part of the beamline. Low current power supplies and Hall probes will be installed on many of the current beamline elements. Many new quadrupoles will be installed.
- Beamline monitoring and particle I.D. will be optimized to reduce material in the beam. This will include a differential Cerenkov counter, beamline TOF and tracking with a pixel silicon station and SciFi detectors.

E. Ramberg slide from Vancouver ILC test beams talk

Beam Specifications

- Particle momentum as low as 1 GeV
- Momentum bite 2% < 5 GeV, 1% >5 GeV
- Beam Spot 1” > 10 GeV, trigger counter determines below 10 GeV
- Parallel section for Cherenkov <0.3 mrad
- Horizontal dispersion 1% dp/p per inch

THE FERMILAB ACCELERATOR COMPLEX



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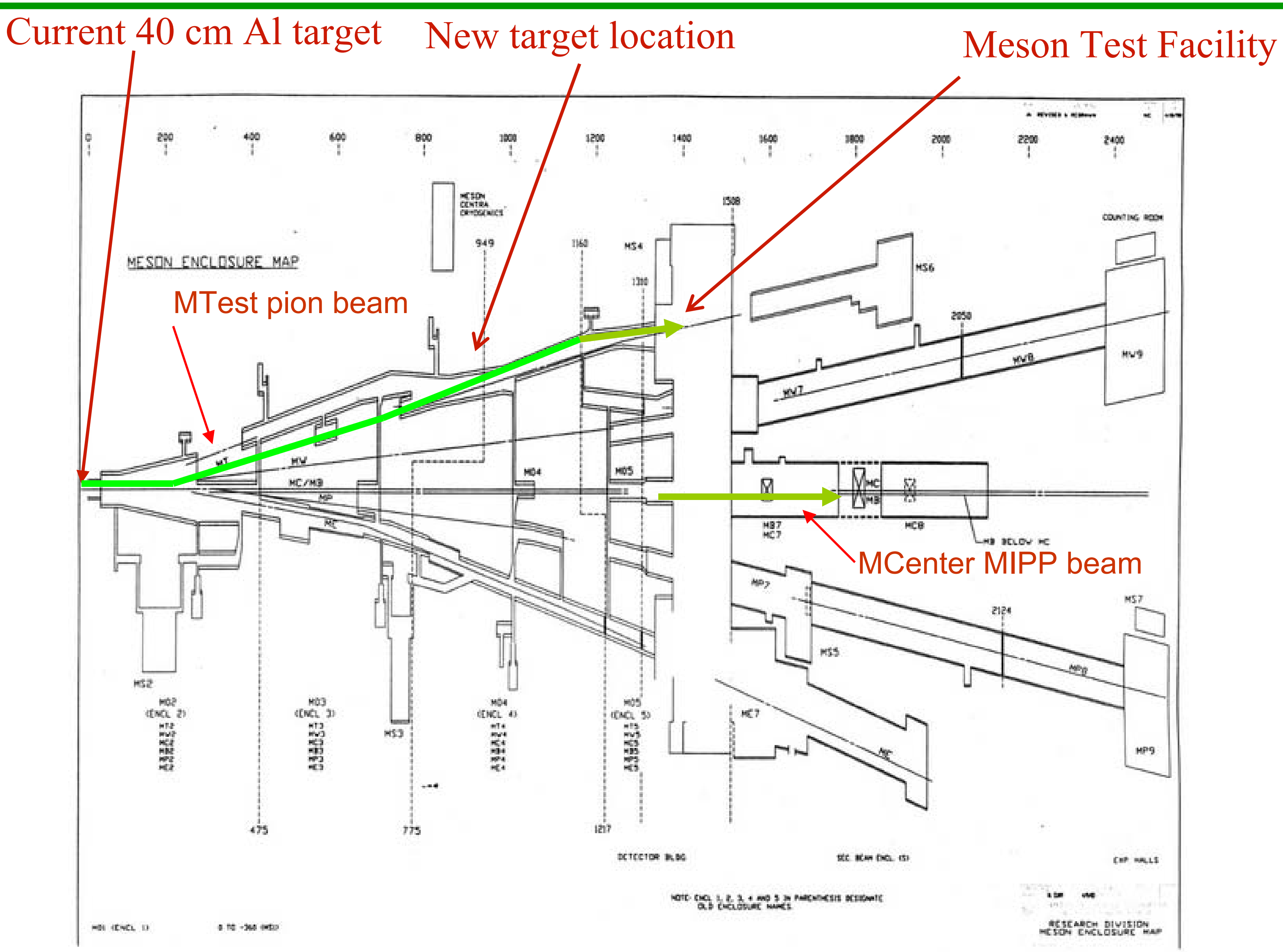
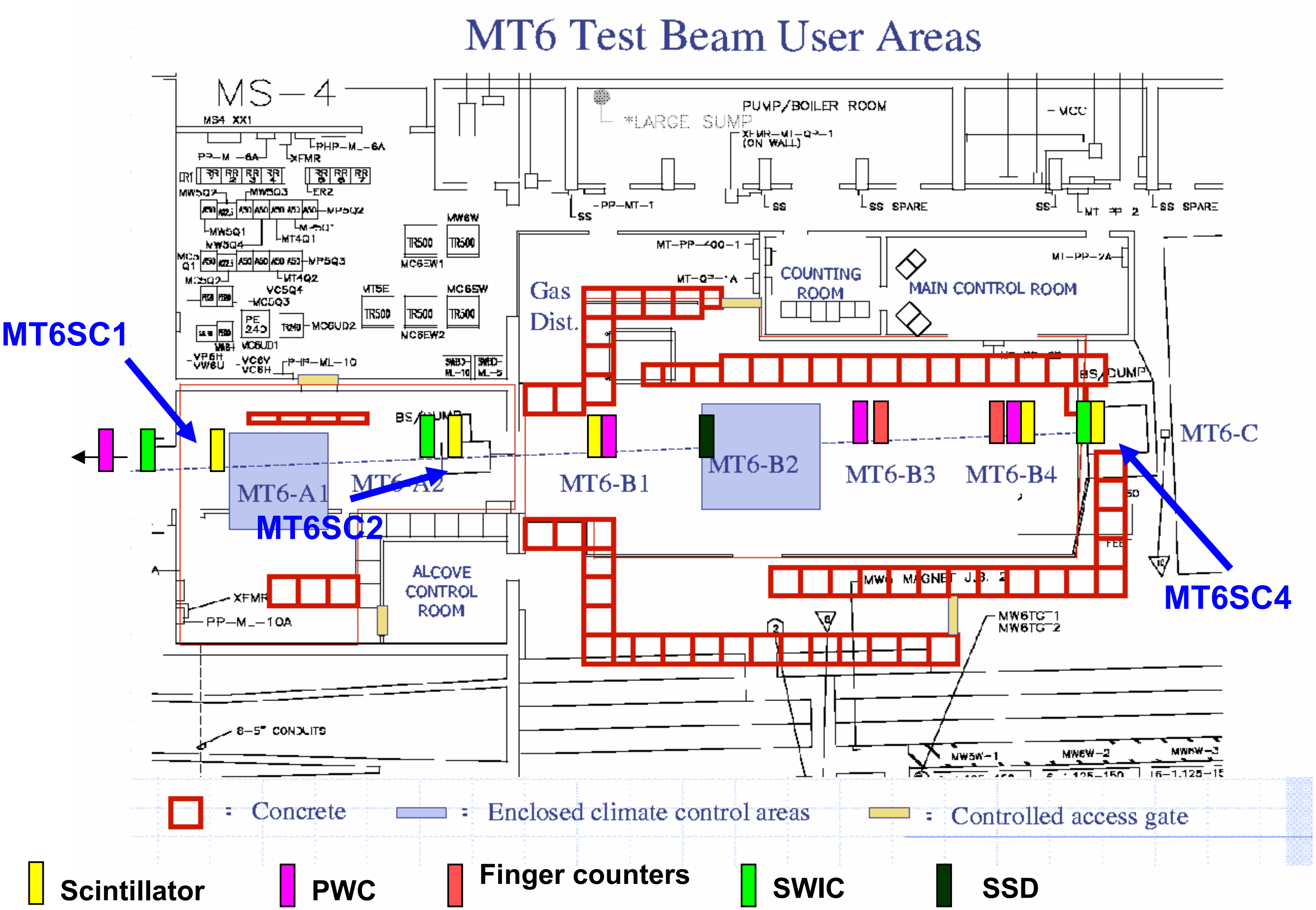
MTest Beam Layout and Modes



MTEST BEAM FACILITY DETECTORS



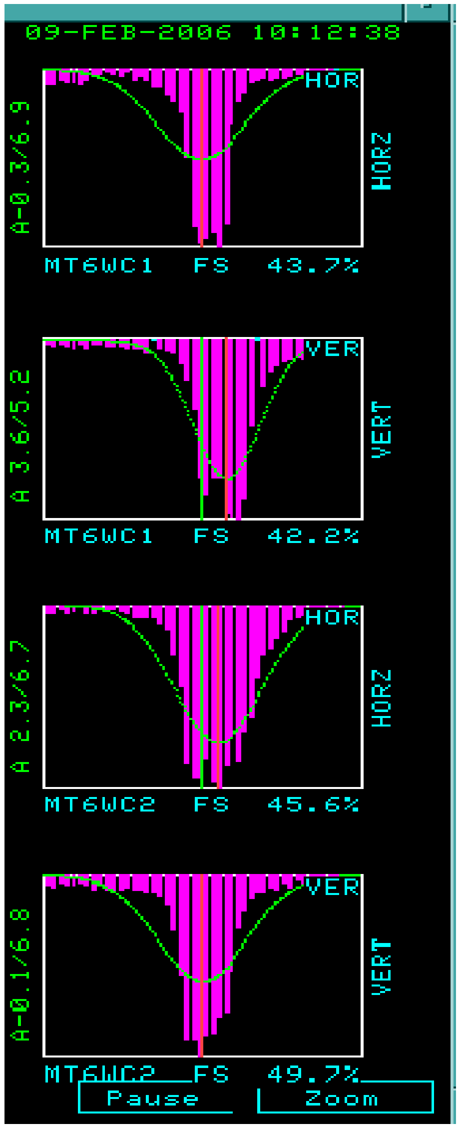
PRESENT RATE IN THE MTEST BEAMLINE

Particle Energy (GeV)	MT6SC2 rate normalized to 1E12 protons/spill	Electron Content
120	~400-450K	---
66	~100K	---
33	~30K	~0.7%
16	~20K	~10%
8	~5K	~30%
4	~700	~60%

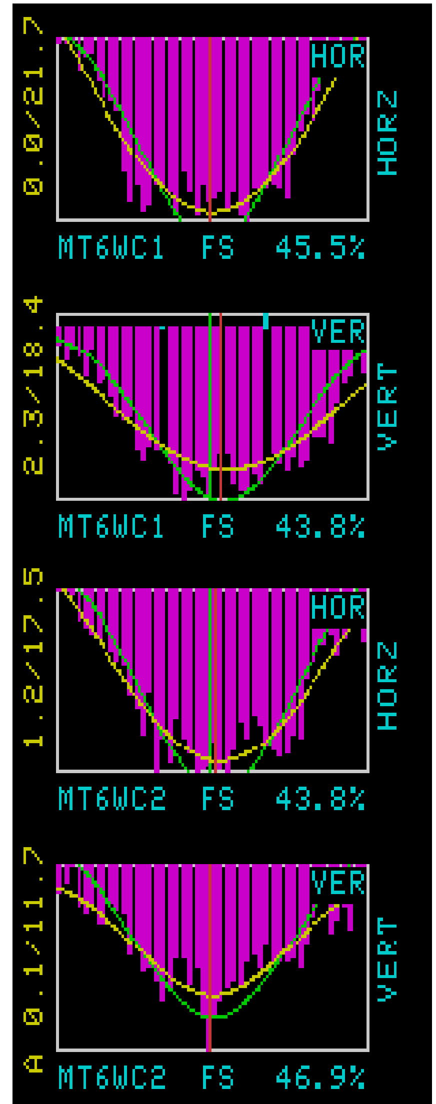
- 4 second long slow spill once per minute 12 hrs/day

MTest Beam Profiles

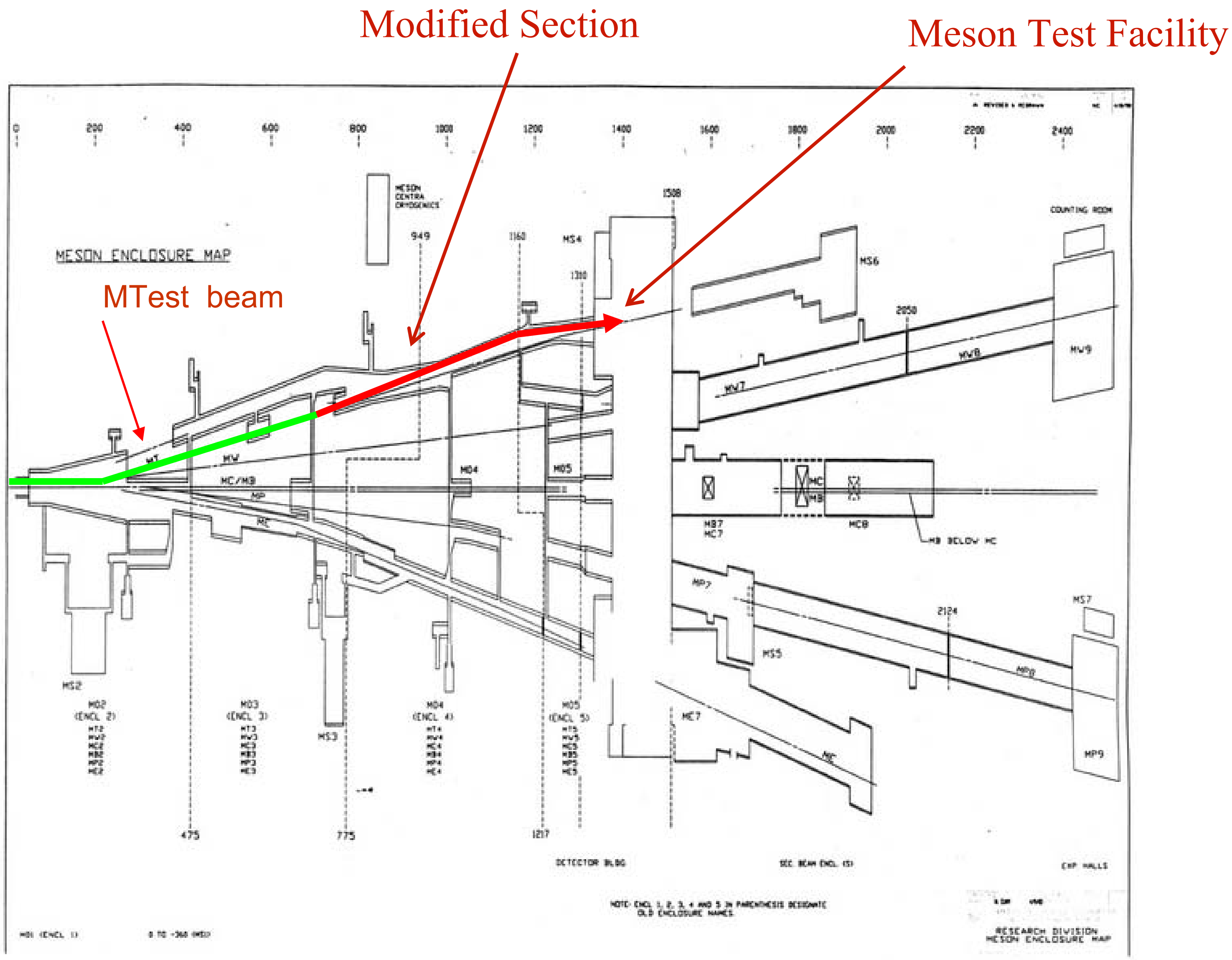
120 GeV proton mode



16 GeV pion mode

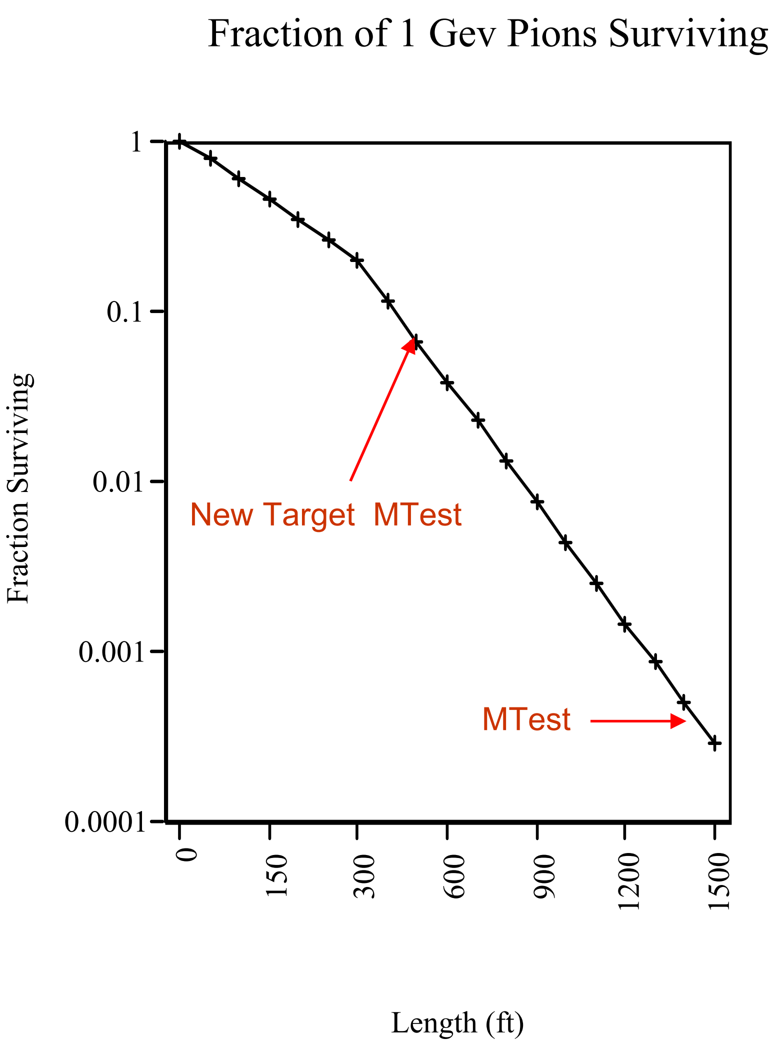


New MTest Beam Layout



1 GeV Pions - Survival vs length

Gain vs Energy



Energy (GeV)	Gain due to Pion Decay factor
1	90
2	9.2
4	3.0
8	1.8
16	1.3
33	1.2
66	1.1

Scheme to reduce material in new design

Summary Material up to MT6SC1

Radiation Lengths (%)

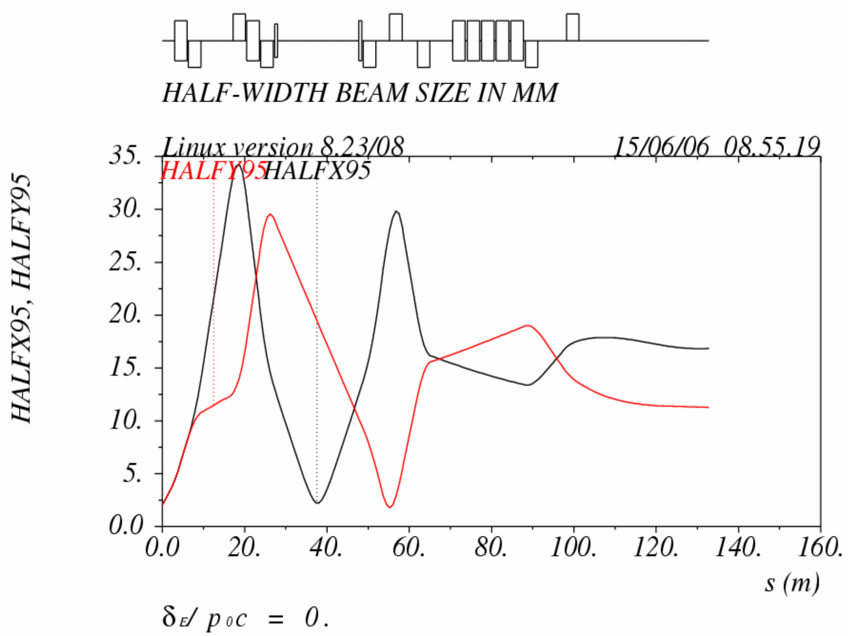
	Current MT	Shorter Line MT3	Min Material
	XR(XI)		
type of material			
air	5.5	1.4	1.1
windows	4.9	3.5	2.3
scintillator	3.8	3.0	0
PWC	3.6	2.1	0
Total	**17.8**	**10.0**	**3.4**

- Recycle/machine existing wire profile monitor(SWIC) vacuum boxes to hold Fiber x,y planes to replace PWC's
- Cherenkovs stacked together with new small diameter flanges to allow thin windows, beam holes for mirrors

Energy (GeV)	Gain due to minimizing material
1	25
2	12
4	2

Beam Optics

- Meets specs on spot size, momentum bite & parallel section for Cherenkov
- Quad doublets replaced by triplets- more flexible tunes
- Quad doublet downstream added to allow independent tuning of Cherenkov region and final spot size



Low Current Mode Power Supplies And Hall Probes

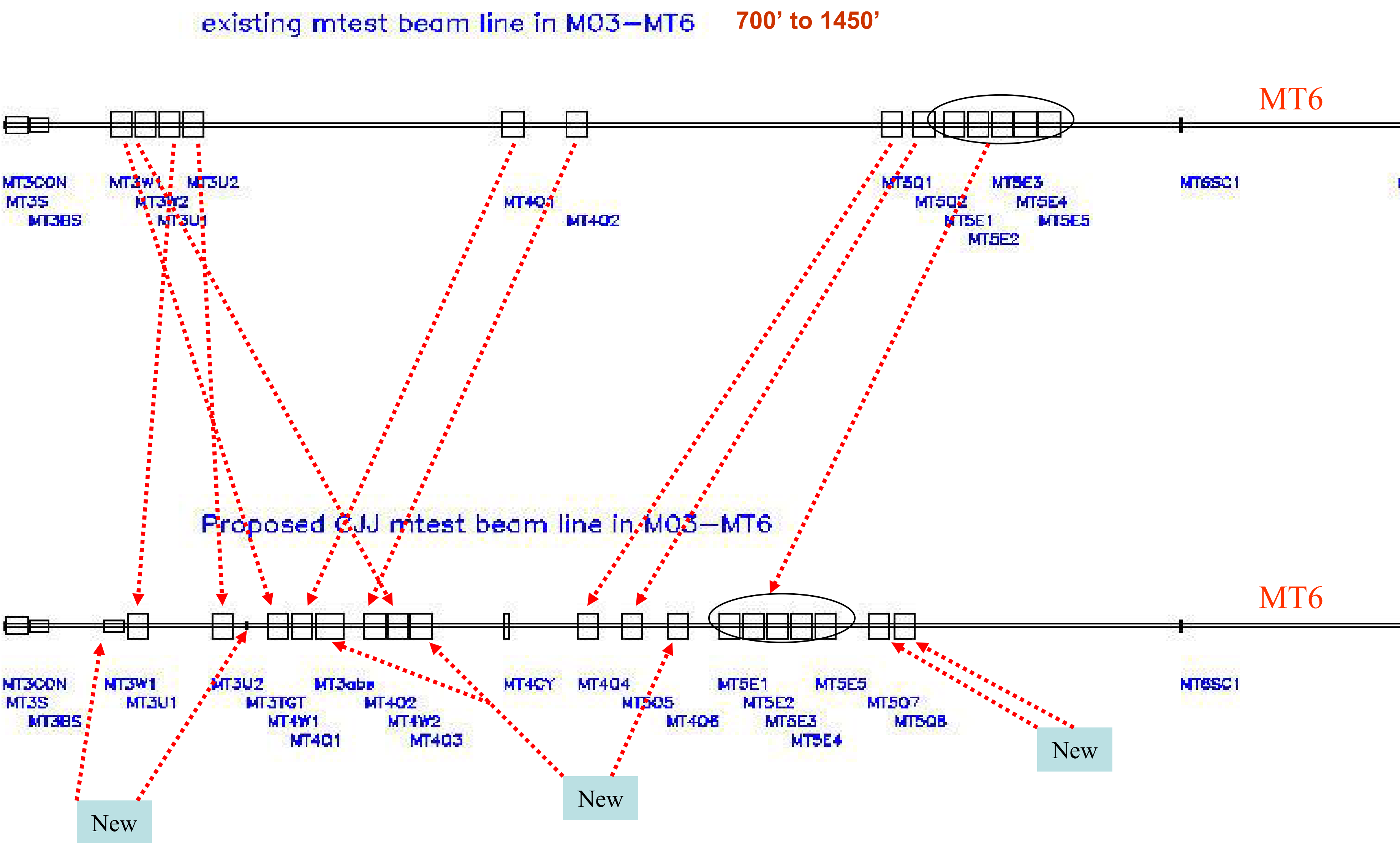
List of Magnets for Mtest - 3 modes shown

	Proton Mode	**Pion Mode high I**	**Pion Mode low I**	**Low Energy Mode high I**	**Low Energy Mode low I**
Magnet	Current amps 120 GeV	Current 66 GeV	Current 4 GeV	Current 30 GeV	Current 1 GeV
MT4W(2)	1220	670	41	305	10
MT4Q1	76	42	2.5	19	0.6
MT4Q2	<100	65	4	30	1.0
MT4Q3	88	48	2.9	22	0.7
MT4Q4	48	26	1.6	12	0.4
MT4Q5	<100	67		30	1.0
MT4Q6	<100	56	3.7	25	0.9
MT5E(5)	1300	715	43	325	11
MT5V	~100				~0.5
MT5Q1	82	45	2.8	20	0.7
MT5Q2	86	47	2.8	22	0.7

Estimated rates in new design

Energy (GeV)	Present Hadron Rate MT6SC2 per 1E12 Protons	Estimated Rate in New Design (dp/p 2%)
1	---	~1500
2	---	~50K
4	~700	~200K
8	~5K	~1.5M*
16	~20K	~4M*
33	~30K	~6M*

Move 13 magnets, add 11 new elements, move beam line transversely including trim magnets, instrumentation, vacuum pumps



Summary

- Design complete for shorter beamline with less material in beam, improved optics, good power supply regulation, and hall probes to monitor low current fields. New low energy pion mode to 1 GeV.
- Rebuilding beamline beginning now, expect about 3 months for rebuild
- And a few weeks of commissioning….
- New low energy pion MTest mode should be ready early next year.

Backup Slides

Fermilab

FNAL-TM-2291

International Linear Collider Calorimeter/Muon Detector Test Beam Program
(A Planning Document for Use of Meson Test Beam Facility at Fermilab)

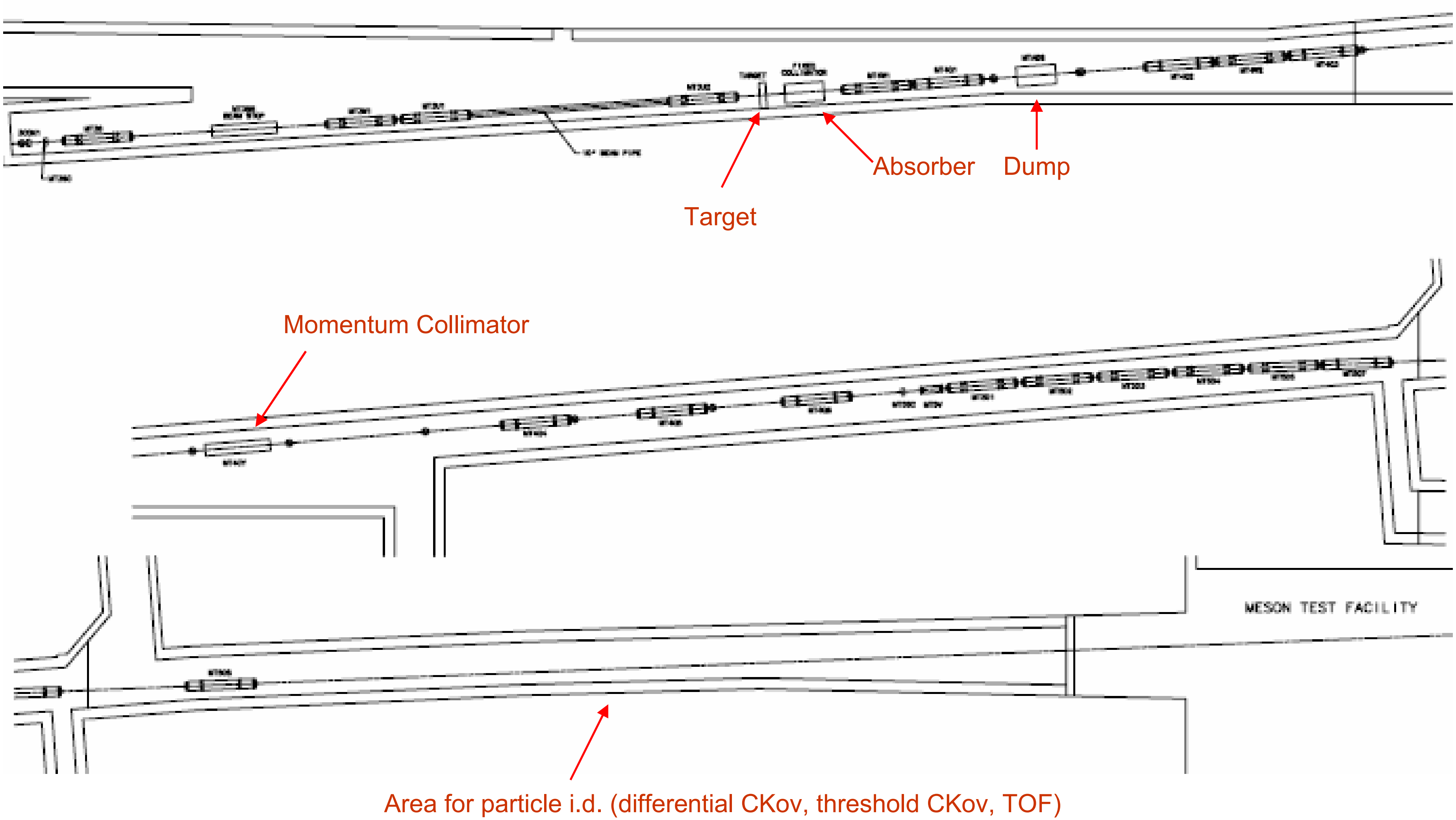
February 22, 2005

J. C. Brient and J. Yu

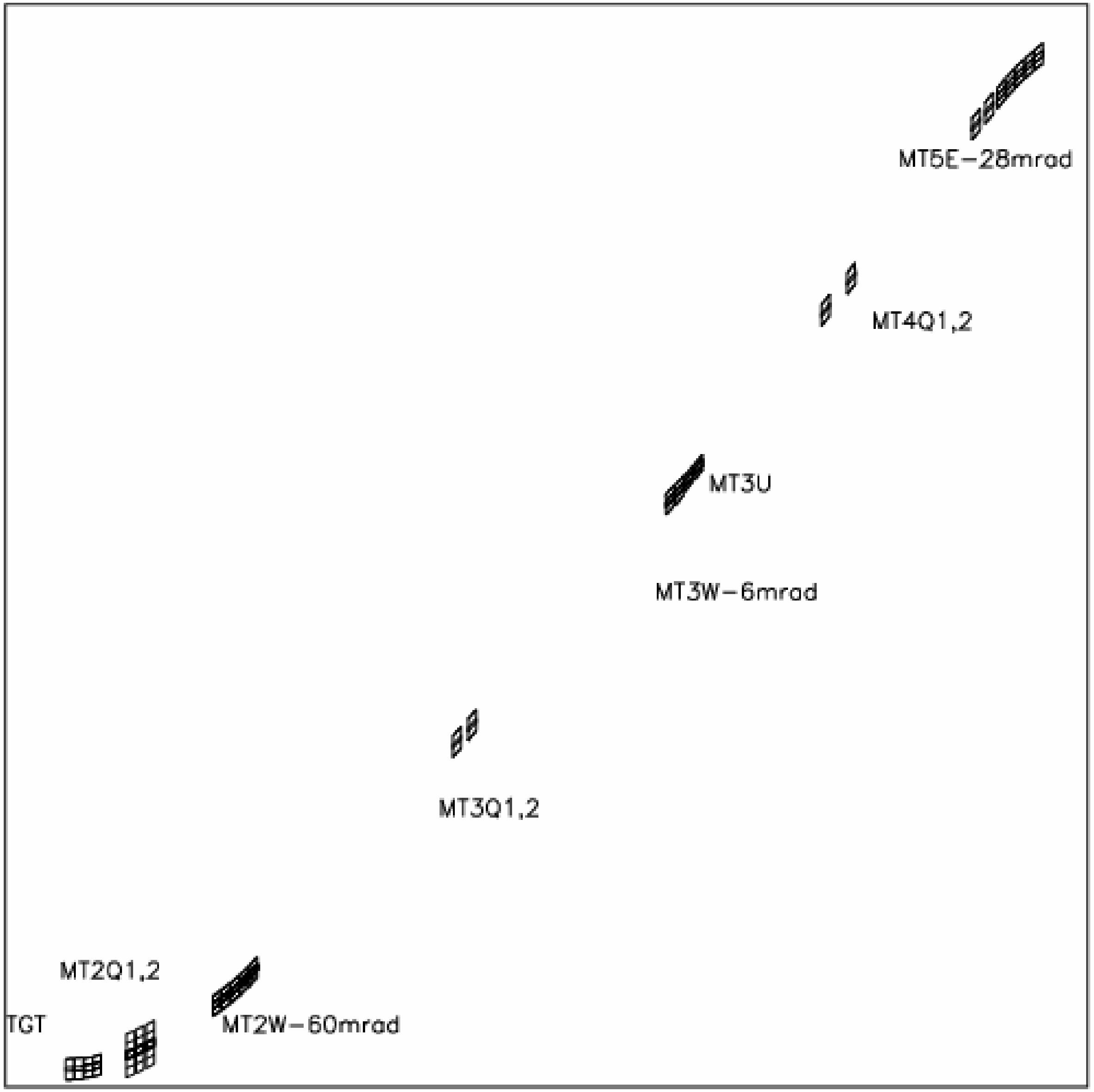
For the ILC Calcrimeter Test Beam Group

- Commissioning and delivery of charge selected beam of pions at low momenta, starting at 3 GeV/c for the first 6 months and down to 1 GeV/c after the initial 6 months of running.
- Commissioning of an electron beam over as extensive a momentum range as possible, starting at 3 GeV/c to 20 GeV/c for the first 6 months and expand to 1 GeV/c and 25 GeV/c after the initial 6 months of running.

New Beamline Layout



Current Mtest layout GEANT picture



Loss due to material in beam

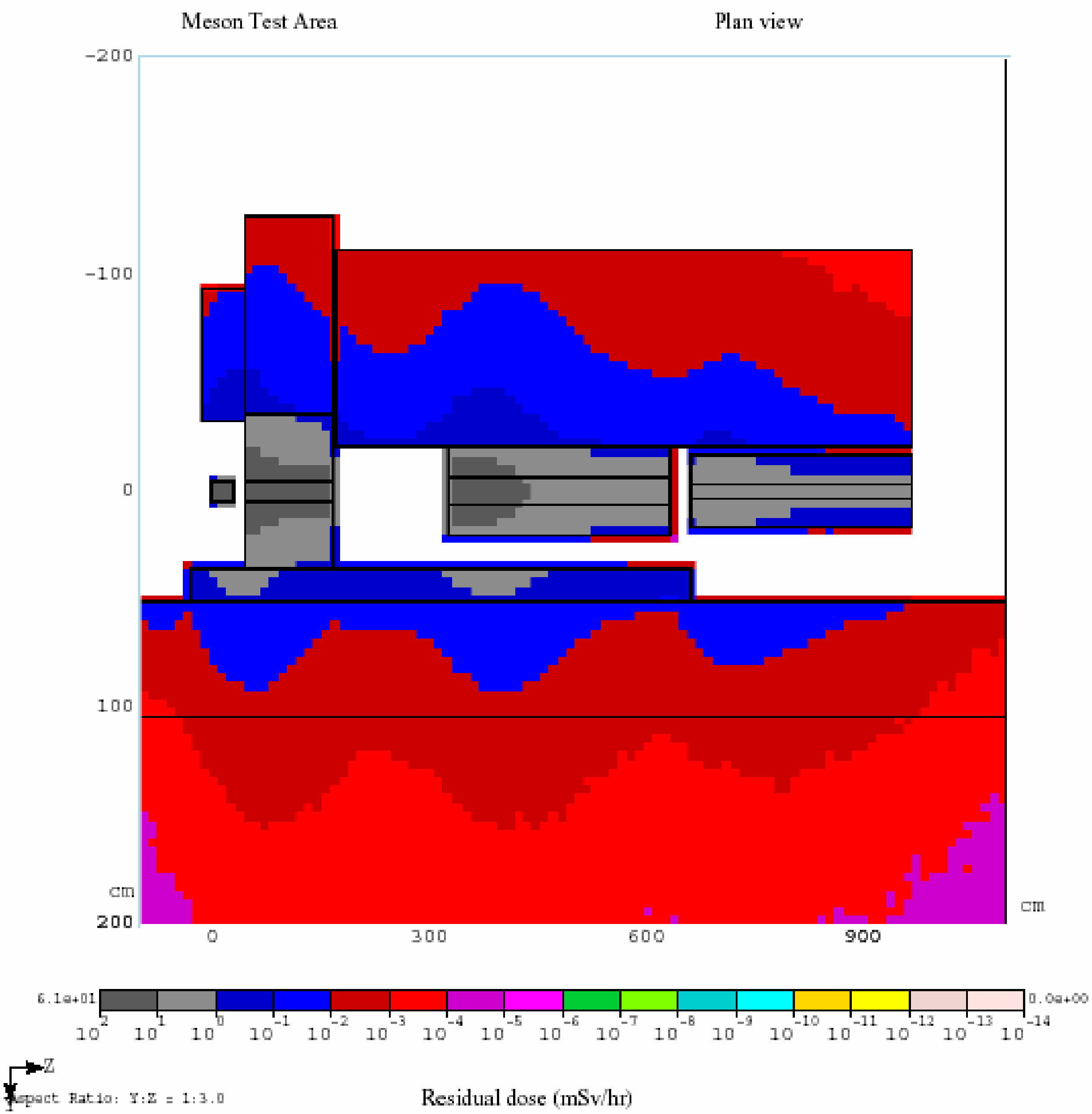
The transmission of secondary beam in the present MT beamline gets degraded due to large air gaps, several windows and various instrumentation materials. It is possible to reduce the total material that the secondary beam encounters. ***A GEANT model was used to study the hadron and electron yields at the standard beamline energies.***

Type of Material	Radiation Length (X_0)	Interaction Lengths (λ)
Air	0.055	0.022
17 Windows	0.049	0.007
Scintillators	0.038	0.020
PWCs	0.036	0.008
Total	0.18	0.057

Materials up to MT6SC1

Energy (GeV)	Hadron Reduction due to Presence of Material in Beam	Electron Reduction due to Presence of Material in Beam
4	25	~90
8	6.4	14
16	2.5	6.3
33	1.4	4.2
66	1.2	1.9

Radiation Safety Calculations using MARS
Igor Rakhno BD/Physics



Comparison of Doublet vs. Triplet Optics

	Doublet	Triplet
• Beam emittance (95%)	1.5 mm-mr	2.7 mm-mr
• Spot size @dp/p collimator	±3 mm	±2.5 mm
• Dispersion @dp/p collimator	0.1 m	0.2 m
• Momentum resolution	±6-12%*	±2%
• Spot size @experiment	±7-17 mm	±6-15 mm
• dp/p – exp spot size	coupled	decoupled
• Parallelism	0.1 - 0.3 mr	0.2 - 0.4 mr
• Dispersion @experiment	2 - 3 m	(variable)